

ANTARCTIC GEOLOGY AND POLAR CLIMATES.

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It seems desirable at the present time of active interest in Antarctic exploration to call attention to a point that deserves the special scrutiny of geologists who may visit far southern regions.

Exploration already accomplished has shown that the Antarctic as well as the Arctic lands contain geological formations indicative of a much milder climate than that which prevails in high latitudes today. Thus far, the evidence of mild polar climates has been drawn almost exclusively from fossils or land plants contained in stratified continental deposits. The structure of non-fossiliferous continental formations at high latitudes has not been minutely studied in their bearing on climatic problems. Investigations of recent years in temperate latitudes have however shown that the detailed structures of land-laid stratified deposits may also be used with much success in determining the climate under which they were formed. The studies of Professor Joseph Barrell, of Yale University, published in the (Chicago) *Journal of Geology* for 1908, deserve especial mention in this connection; for they have clearly set forth the characteristics of continental formations in contrast to marine formations, and they have further suggested a variety of tests by which the climate under which continental deposits were formed may be inferred. Under an ordinary or normal climate, neither glacial nor arid, land-laid stratified deposits are chiefly the work of aggrading streams, and as such they will be characterized through the greater part of their mass by frequent and irregular changes in texture, with cross-bedding, lateral unconformities, red color, ripple marks, rain prints and mud cracks. Evidently then the detailed structure of continental formations in high latitudes may be nearly as significant of mild climate as is the occurrence of fossil land plants. Furthermore, the formation of

continental deposits is greatly favored by large continental area; and conversely, large continental area may be inferred from an abundance of continental deposits; thus the problem of polar climates is linked with the equally interesting problem of the changes in land and sea areas through geological time.

There is an important theoretical matter to be mentioned in this connection. It will be remembered that Professor T. C. Chamberlin presented a communication at one of the April meetings of this society several years ago, in which he suggested that a mild polar climate might be caused by a reversal of the deep oceanic circulation, whereby the warm surface waters of the torrid belt would sink, creep along the bottom toward either pole, and rise in high latitudes, where their warmth would determine a climate very much milder than that of today. Evidently if this or any other process that is capable of producing a mild polar climate has been in operation at one time in the past, it may have been in operation at various other times; and thus a question rises to which Mr. Bailey Willis drew attention in his address before the geological section of the American Association at the Boston meeting of last winter; namely, what has been the prevailing climate of the polar regions through the geological ages? Naturally we open this inquiry with a predisposition to regard the climate now prevailing in high latitudes as the normal climate; but if it once be shown that a mild climate has sometimes prevailed there, it is entirely possible that a mild climate and not the rigorous climate of today really represents the prevalent conditions of the polar regions through geological time. Under Chamberlin's theory of mild polar climate, rain would be abundant but mud cracks would be rare; hence even so small a detail as the relative proportion of these minute structures in continental formations of high latitudes would have its significance. Marine formations will probably give less decisive evidence in this respect than continental formations; but marine formations would also have their importance, not only by reason of the fossils they might contain, but perhaps even more from the presence or absence of scattered boulders and gravels, such as might be dropped on a sea floor from floating icebergs. The prevailing absence of such intermixture of floated materials in the marine for-

mations of former polar sea would be almost as significant as the occurrence of fossil land plants in the continental formations of high latitudes.

It is certainly very suggestive that the stratified formations of high latitudes have already repeatedly yielded evidence of mild climates, chiefly as above noted in the form of fossil land plants contained in continental formations, partly in the form of red sandstones; and it is certainly striking that little or no evidence of ancient glacial climates in the polar regions has been found either in continental formations in the form of tillite lying on striated rock-floors, or in marine formations in the form of coarse materials scattered through fine-textured sediments. The inference thus warranted in favor of not infrequent mild polar climates ought to be followed up by critical examination of all pertinent evidence, such as the detailed structure of non-fossiliferous continental formations in high latitudes may furnish.

Antarctic exploration is of particular importance in this respect; for the Antarctic regions are today at least of continental habit, in contrast to the Arctic regions which are, on the other hand, of oceanic habit. Speculations are already abundant as to the formerly much greater extension of Antarctic lands, so as to form connections with other continental masses; and on the present remnant of so greatly extended an area, the possibility of finding continental formations is increased. It therefore seems fitting to bring this matter before that Society which, more notably than any other in the United States, has recently taken active steps in promoting American participation in Antarctic work; with the suggestion that it should be presented to the attention not only of American geologists who undertake southern voyages, but also of the geologists in expeditions sent out by other countries. The problem thus offered for investigation may fairly be regarded as one that has far-reaching results; for if it should appear that the earth's polar climates have really been prevailing mild, we should have to frame new conceptions of terrestrial physics.